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Formulating Conversion Tables for Stick-Measure of Sacramento Precipitation Storage Gages

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Sacramento precipitation storage gages are usually built to specifications by local sheet metal companies where quality control is limited. This Note presents two mathematical models for estimating precipitation measured in locally constructed gages. A calibration technique is also described.

Keywords: Precipitation, storage gages, rain gage.

Sacramento precipitation storage gages are used in mountainous terrain where precipitation records are needed but visits are infrequent and snowcapping can be a problem (Kidd 1960; U.S. Corps of Engineers 1956; Warnick 1961). This Note presents two mathematical models for estimating amount of precipitation at any measured depth for any size gage and describes a gage calibration technique.

The Sacramento gage is conical in shape, typically having an 8-inch diameter orifice, a 20-inch diameter base, and a sidewall slope of 6:1. The conical gage (fig. 1) has several advantages. It offers a large storage capacity with a small orifice, provides good mixing properties for dissolving snow into an antifreeze-antievaporant solution, and the shape discourages snowcapping (Billones 1963; U.S. Corps of Engineers 1956).

The gages are not fabricated by any particular company, and must be built to specifications (Codd 1947) by local sheet metal companies. Quality control is limited and generalized rating tables are not likely to match the locally constructed gage. However, a set of gages manufactured together are usually consistent, in which case one rating table or curve will be applicable to the set.

Rating curves for the Sacramento storage gage are curvilinear. They reflect both the shape of the gage and the amount of precipitation which may enter a fixed diameter orifice.

Figure 1.—A 100-inch Sacramento storage gage in use on the Beaver Creek watershed, Arizona.

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The two mathematical models for estimating precipitation are:

(1) $P = b_o + b_1 d + b_2 d^2 + b_3 d^3$
(2) $P = b_o + b_1 (t - d)^3$
where
P = estimated precipitation
d = depth of precipitation in the gage
t = total height of a theoretical cone from the base, extending beyond the orifice to an apex

Total height (t) can be calculated by the equation

$$t = hr_b/(r_b - r_o)$$

where
h = the height of the gage
r_b = radius of the base
r_o = radius of the orifice.

Any desired units of depth and precipitation may be used to determine the equation coefficients, since the coefficients reflect the units used. Theoretically, the b_o term should be equal to zero. However, distortion of the gage with added precipitation, drain valves, and other imperfections requires a b_o term to be calculated so that a rating equation may more closely fit the physical situation.

Equation 2 is recommended. Equation 1 is a third degree polynomial, and calculating its coefficients is tedious and time consuming without a computer. Equation 2 only requires a simple transformation of one independent variable, and calculation of its regression coefficients is fairly simple. It is used on the Beaver Creek watersheds in Arizona.

Two sets of gages have been built for Beaver Creek. Each set required a different rating equation. The rating equations were derived by adding known increments of water to four randomly selected gages from each set, and measuring the solution depth after each addition (Garstka et al. 1958).

The set of gages built in 1960 have sidewall slopes of 8.5:1. Their rating equation, for precipitation (P) in inches at any given depth (d) in feet, is:

$$P = 102.97961 - 0.55167\ (5.7059 - d)^3$$

The set of gages built in 1972 have sidewall slopes of 7.2:1. Their equation is:

$$P = 110.91541 - 0.70533\ (5.3998 - d)^3$$

The r^2 for both equations was 0.9998.

Rating tables used by National Weather Service are based on a sidewall slope of 6:1. Partly because of sideslope differences, applying the National Weather Service tables to the 1960 gages overestimates Beaver Creek precipitation by 20 to 30 percent. Similarly, the equation for the 1960 gages underestimates precipitation measured by the 1970 gages by 10 percent (table 1). Thus it is readily apparent that each set of gages requires its own rating curve.

Table 1.--Precipitation (inches) in Sacramento storage gages for given depths of solution

Depth of solution (ft)	Amount of precipitation		
	National Weather Service	1960 gages	1972 gages
0	0	0.5	-0.1
.5	35.0	25.1	27.9
1.0	63.1	45.5	50.8
1.5	85.1	61.9	69.1
2.0	101.8	74.9	83.2
2.5	113.8	84.8	93.7
3.0	122.0	92.0	101.2

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